Physics 512 (Fall 2006)

HOMEWORK 4

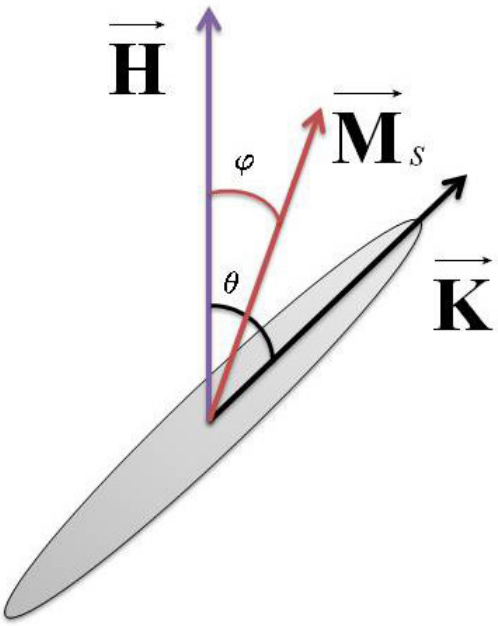
due 9/26/06

Superparamagnetic nanoparticle: The Stoner-Wohlfarth model

Consider a ferromagnetic nanoparticle with a magnetic moment M_s, volume V and anisotropy energy density K. Magnetic field is applied along $z-$ axis and particles's easy axis makes a **fixed** angle θ with the field. Magnetic moment of such particle will be at some angle φ.

The magnetic energy of such particle is then approximated by

$$E = KV \sin^2(\theta - \phi) - HM_s \cos(\phi)$$



a) Plot the magnetization loops, $M(H)$, by considering magnetic field changing in a cycle as $H_{\max} \to -H_{\max} \to H_{\max}$ for $\theta = 0$ and for $\theta = \pi/2$. (remember, M is measured along the magnetic field direction). Determine minimum $H_{\max}$ required to have full hysteresis loop. **(40 points)**

b) Write down AC susceptibility (both real and imaginary parts of all harmonics) for both angles $\theta = 0$ and $\theta = \pi/2$. (Assume $H = H_{ac} \cos(\omega t)$). **(40 points)**

c) Calculate energy loss per cycle for $\theta = 0$, and $\theta = \pi/2$.**(10 points)**

d) What, in your opinion, are the primary mechanisms of the anisotropy K for a particle shown in the picture? **(10 points)**